

# (12) UK Patent Application (19) GB 2 313 741 A

(43) Date of A Publication 03.12.1997

(21) Application No 9707802.6

(22) Date of Filing 17.04.1997

(30) Priority Data

(31) 08653895

(32) 28.05.1996

(33) US

(51) INT CL<sup>6</sup>  
H04M 1/72 // H04Q 7/32

(52) UK CL (Edition O )

H4L LECTP

G4H HRBE HRCA H1A H13D H14A H14G H60  
U1S S2196

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(56) Documents Cited

EP 0473465 A1 WO 96/03811 A1 WO 95/10153 A1  
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(58) Field of Search

UK CL (Edition O ) H4L LECTP LECTX  
INT CL<sup>6</sup> H04M 1/72 , H04Q 7/32

ONLINE DATABASE: WPI

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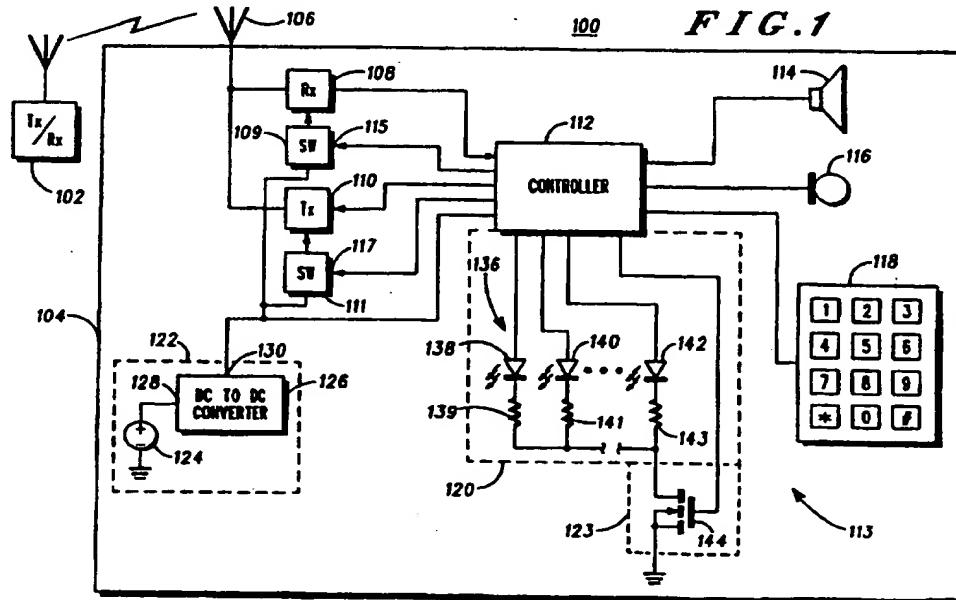
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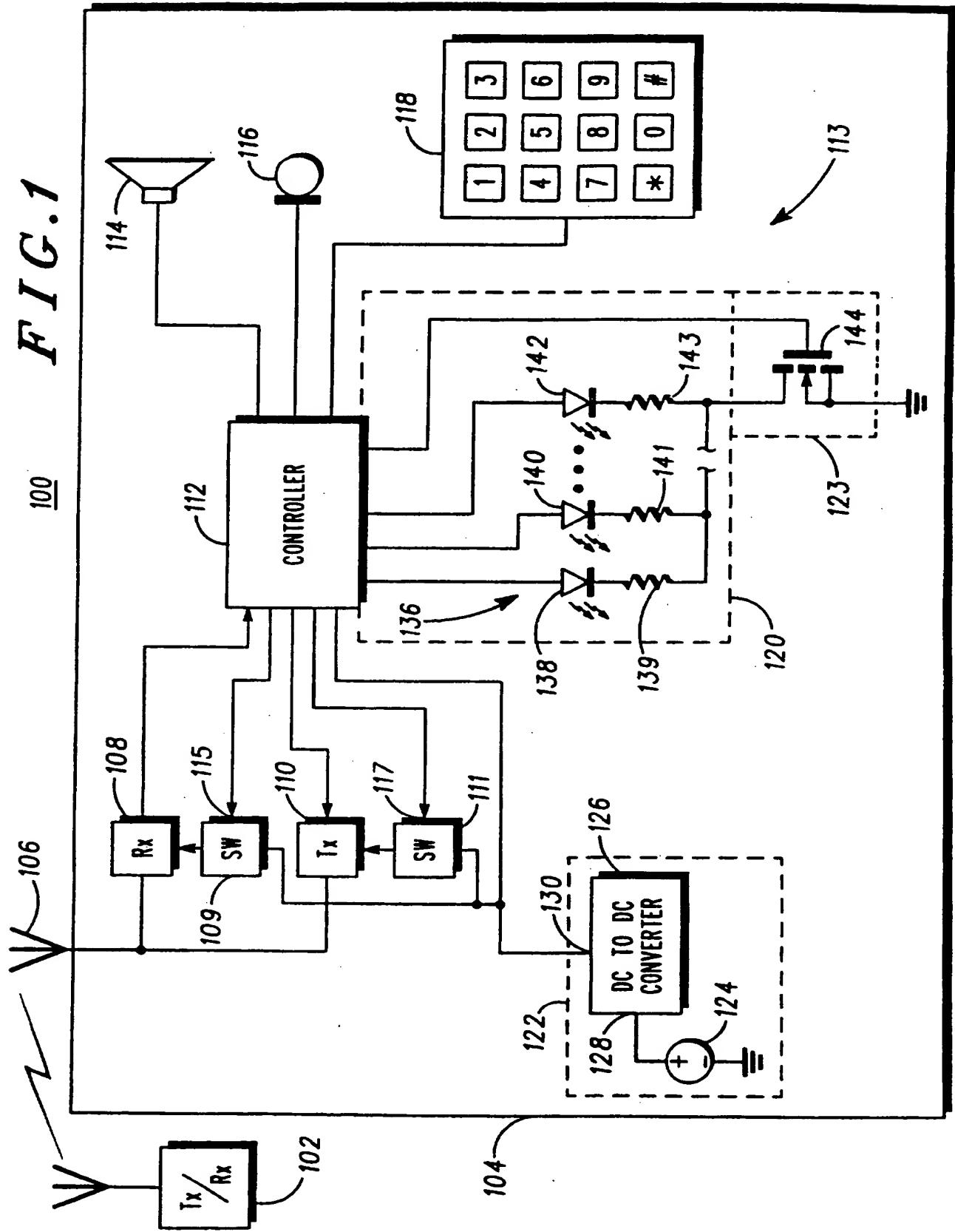
## (54) Peak current reduction in a communication device

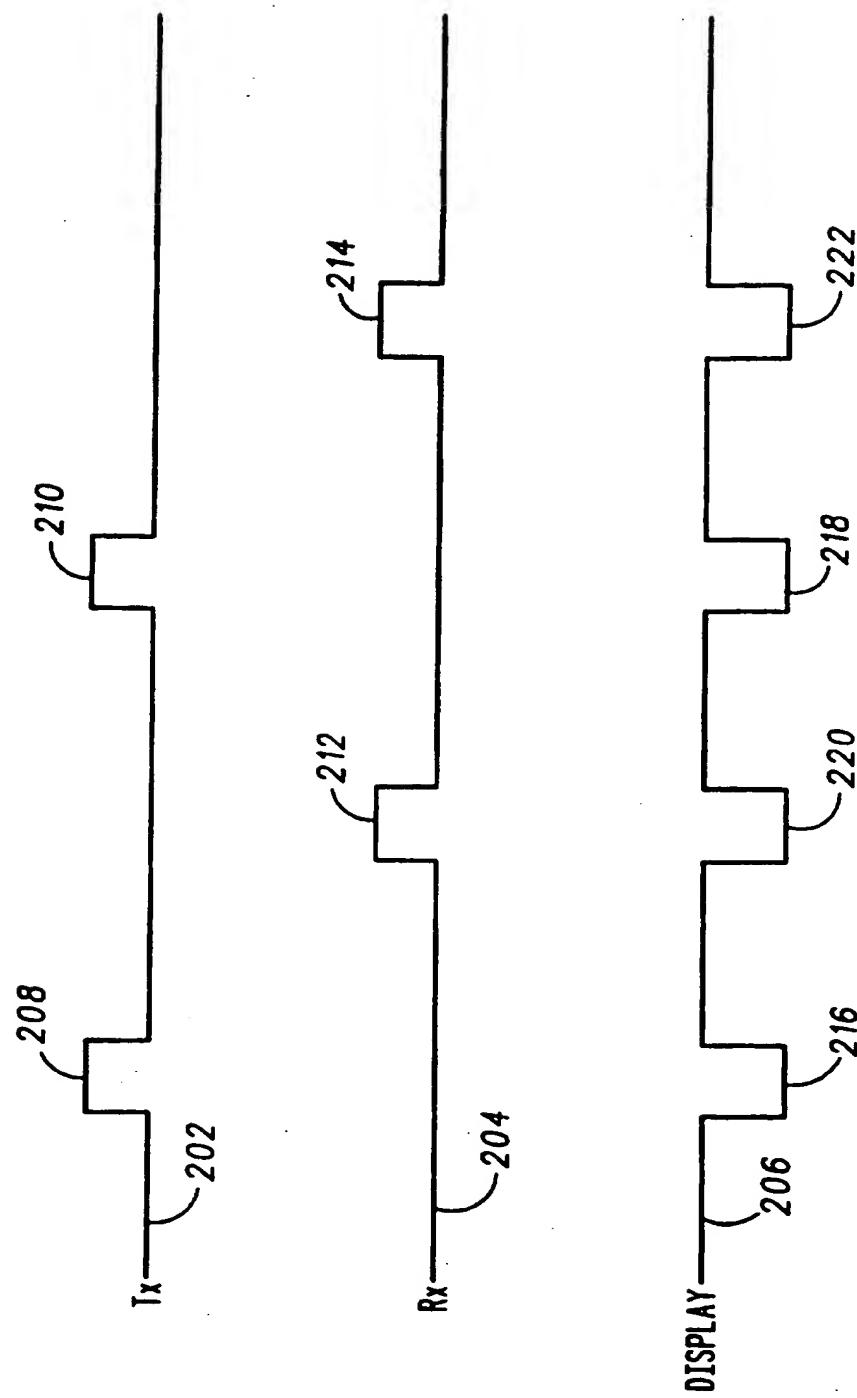
(57) In a communication device such as a cordless telephone 104, the peak current drawn from the battery 124 is reduced by selectively switching off parts of the device during transmission and preferably also reception of radio frequency signals. By doing this the voltage converter 128 remains within its region of maximum efficiency, thus extending battery life. In a TDMA system, operating power is removed from the display 120 using switch 123 during transmit and receive time slots without it being perceptible to an user. The time intervals over which power is removed may be longer or shorter than the transmit or receive time slots. Operating power is also provided to the transmit circuit 110 and receive circuit 108 during respective transmit and receive time slots only, via switches 111 and 115 respectively. The device may also be a pager or any other current sensitive battery powered device.



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FIG. 1





**FIG. 2**

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## PEAK CURRENT REDUCTION IN A CORDLESS TELEPHONE HANDSET

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The present invention relates generally to communication devices. The present invention relates more particularly to reduction of peak current in a communication device such as a cordless telephone handset.

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### Background of the Invention

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Many communication devices operate on battery power. For the convenience of the user, communication devices may be designed for use with commonly available batteries, such as "AA" or "AAA" cells. Two such cells in series provides an approximately 3.0 volt DC battery voltage. The communication device includes a DC-to-DC voltage converter to step up the battery voltage to an operating voltage, such as 5.0 volts. The voltage converter thus provides the operating voltage for the communication device.

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Such voltage converters are not one hundred percent efficient, however. One commonly available voltage converter is approximately 80% efficient over an output current range of several hundred millamps (mA). Efficiency is the ratio of the output power to the input power for the voltage converter. For output currents above about 600 mA, converter efficiency falls off rapidly. These values are representative only. Other voltage converters will have other efficiencies and other operational limitations.

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The effect of reduced voltage converter efficiency at high current is increased power drain from the battery. As output current from the voltage converter increases, current drain from the battery increases proportionate to efficiency. If efficiency decreases as the output current increases, the current drawn from the battery will increase proportionately with both increasing output current and decreasing efficiency. Thus, at high current, the battery discharge rapidly, inconveniencing for the user.

5           Communication devices can be designed with low power  
dissipation to keep the current drawn from the voltage converter in a  
range of greatest efficiency. However, as portions of the communication  
device switch on and off, peak current drawn from the voltage converter  
may temporarily move the voltage converter into a low efficiency range.  
10          If such peaks occur frequently or are sustained in duration, the batteries  
will discharge rapidly.

15          Accordingly, there is a need for a method and apparatus for  
reducing the magnitude and duration of current peaks drawn from a  
voltage converter in a communication device.

15          Brief Description of the Drawings

20          The features of the present invention, which are believed to be  
novel, are set forth with particularity in the appended claims. The  
invention, together with further objects and advantages thereof, may best  
be understood by making reference to the following description, taken in  
conjunction with the accompanying drawings, in the several figures of  
which like reference numerals identify identical elements, and wherein:

25          FIG. 1 is an operational block diagram of a communication system  
including a communication device with which the present invention may  
be used; and

30          FIG. 2 is a timing diagram illustrating operation of the  
communication device of FIG. 1 in accordance with the present invention.

30          Detailed Description of a Preferred Embodiment

35          Referring now to FIG. 1, it shows a block diagram of a  
communication system 100. The communication system 100 includes a  
remote transceiver 102 and a communication device, radiotelephone  
handset 104. The remote transceiver 102 sends and receives radio  
frequency (RF) signals to and from radiotelephone handsets within a fixed  
geographic area. The RF signals include digital data transmitted serially  
and modulated by a carrier frequency. The radiotelephone handset 104 is  
one such radiotelephone handset contained within the geographic area.

40          The radiotelephone handset 104 includes an antenna 106, a receive  
circuit 108, a transmit circuit 110 and a controller 112. The controller 112 is

5 coupled to other elements of the radiotelephone handset 104 by control lines, not all of which are shown in FIG. 1. The radiotelephone handset 104 further includes a user interface 113, including a speaker 114, a microphone 116, a keypad 118 and a display 120. The radiotelephone handset 104 still further includes a power source 122 and a switch 123.

10 Upon reception of RF signals, the radiotelephone handset 104 receives the RF signals through the antenna 106. The antenna 106 and receive circuit 108 convert the received RF signals into electrical baseband signals and provide corresponding data to the controller 112. The controller 112 formats the data into recognizable voice or information for 15 use by user interface 113. The user interface 113 communicates the received information or voice to a user.

Upon transmission of radio frequency signals from the radiotelephone handset 104 to the remote transceiver 102, the user interface 113 transmits user input data to the controller 112. The controller 20 112 formats the information obtained from the user interface 113 and transmits it to the transmit circuit 110 for conversion into RF modulated signals. The transmit circuit 110 conveys the RF modulated signals to the antenna 106 for transmission to the remote transceiver 102.

In one embodiment, the radiotelephone handset 104 comprises a 25 cordless telephone handset configured for communication with the remote transceiver 102 according to a time division, multiple access (TDMA) communication protocol. For example, the system 100 may operate according to the Digital European Cordless Telecommunication (DECT) protocol. Alternatively, the system 100 may operate according to the Personal Handy Phone System (PHS) protocol, used in Japan, or any 30 other data communication protocol for cordless or cellular telephone systems. Such a protocol defines transmit time slots, for transmission from the radiotelephone handset 104 to the remote transceiver 102, and receive time slots for transmission from the remote transceiver 102 to the radiotelephone handset 104. Operation of the radiotelephone handset 104 35 in conjunction with such transmit time slots and receive time slots will be described in more detail below in conjunction with FIG. 2.

Associated with the receive circuit 108 is a switch 109. The switch 40 109 is coupled between the power source 122 and the receive circuit 108. The switch 109 has a control input 115 for receiving a receiver power control signal from the controller 112. In response to the receiver power

control signal, the switch 109 removes power from the receive circuit 108. Similarly, associated with the transmit circuit 110 and coupled between the transmit circuit 110 and the power source 122 is a switch 111. The switch 111 has a control input 117 coupled to the controller 112 for receiving a transmitter power control signal. In response to the transmitter power control signal, the switch 111 removes power from the transmit circuit 110. The switch 109 and the switch 111 may be implemented in any suitable manner, including incorporating software interoperation with hardware elements of the radiotelephone handset 104, and may remove power only from high-current portions of the receive circuit 108 and the transmit circuit 110.

The display 120 includes a plurality 136 of light emitting diodes coupled in series with the switch 123. The plurality 136 of light emitting diodes includes light emitting diodes 138, 140 and 142. Each of the light emitting diodes 138, 140, 142 is coupled in series with an associated current limiting resistor, including resistors 139, 141, 143. In one embodiment, twelve light emitting diodes are included in the communication device, only some of which are shown in FIG. 1 so as to not unduly complicate the drawing figure. The light emitting diodes 138, 140, 142 are coupled to the controller 112 and are illuminated in response to control signals received from the controller 112. The light emitting diodes 138, 140, 142 include light emitting diodes which form the display, such as seven segment light emitting diodes for displaying alphanumeric characters, and individual light emitting diodes for providing a visual indication to a user of the radiotelephone handset 104. In addition, the light emitting diodes 138, 140, 142 includes one or more light emitting diodes for illuminating the keypad 118 by backlighting the keypad 118. Preferably, the light emitting diodes 138, 140, 142 draw only a relatively small operating current from the power source 122. In one embodiment, each light emitting diode draws approximately 5 mA from the power source 122 when illuminated. Thus, twelve light emitting diodes draw 60 mA from the power source 122.

The switch 123 comprises a MOSFET (metal-oxide-semiconductor field effect transistor) 144. The switch 123 selectively decouples the display 120 from the power source 122 in response to a display control signal from the controller 112. The light emitting diodes 138, 140, 142 included in the display are coupled together at a common node 146. The drain of the MOSFET 144 is coupled to the common node 146 and the source of the

5 MOSFET 144 is coupled to ground potential. The gate of the MOSFET 144  
is coupled to the controller 112 for receiving the display control signal.  
When the display control signal is a high voltage level, the MOSFET 144 is  
turned on, permitting current flow in the light emitting diodes 138, 140,  
142. When the display control signal is a low voltage level, the MOSFET  
10 144 is turned off, interrupting current flow in the plurality 136 of light  
emitting diodes in response to the control signal from the controller 112. If  
the keypad 118 is backlit or otherwise illuminated by one or more light  
emitting diodes, the switch 123 including the MOSFET 144 interrupts  
current flow in the one or more light emitting diodes in response to the  
15 display control signal.

The power source 122 provides operating power for the radiotelephone handset 104. The power source 122 includes a battery 124 and a voltage converter 126. The battery 124 is any suitable battery. For user convenience, the battery 124 is one or more "AA" or "AAA" cells of the type which is commonly available. Such cells are light weight and store substantial charge to provide long operating life for the radiotelephone handset 104. To further enhance user convenience, the cells may be rechargeable. The battery 124 may comprise two such cells coupled in series to provide an approximately 3.0 volt DC battery voltage.

25 The voltage converter 126 is a DC-to-DC voltage converter. The voltage converter 126 has an input 128 for receiving the battery voltage and an output 130. The voltage converter 126 generates an output current at an operating voltage for the radiotelephone handset 104. A typical value for the battery voltage is 3.0 VDC and a typical value for the operating voltage in 5.0 VDC. The voltage converter 126 is preferably a LT1302 voltage converter available from Linear Technology Corporation, Milpitas, California.

35 The voltage converter 126 has an operating region of maximum efficiency. The voltage converter 126 nominally has an efficiency of 80 percent up to an output current of approximately 600 mA. The efficiency is the ratio of output power to input power. Keeping the battery voltage substantially constant and the operating voltage substantially constant, the efficiency is therefore a ratio of the current drawn from the battery and the output current. At an output current of 600 mA, the battery current is approximately 750 mA. Beyond the output current of 600 mA, the efficiency falls off rapidly and the battery current increases rapidly.

5 Therefore, it is desirable to operate the radiotelephone handset 104 at or below a peak current corresponding to an output current from the voltage converter of 600 mA. Thus, the voltage converter 126 has a maximum operating current of 600 mA. These numbers are illustrative only. Other voltage converter models will perform differently.

10 The transmit circuit 110 has relatively high power consumption. Similarly, the receive circuit 108 also has relatively high power consumption. To reduce the overall power consumption in the radiotelephone handset 104, the transmit circuit 110 and the receive circuit are powered down during times when these circuits are not active.

15 If the radiotelephone handset 104 is operating in a communication system according to a TDMA communication protocol, the TDMA protocol creates ideal opportunities for powering down the transmit circuit 110 and the receive circuit 108. As noted above, a TDMA protocol defines transmit time slots and receive time slots for communication between the radiotelephone handset 104 and the remote transceiver 102. For example, a radiotelephone handset operating according to the DECT protocol transmits for transmit time intervals having a duration of 438  $\mu$ sec every 10 msec. To reduce power consumption in the radiotelephone handset 104, the radiotelephone handset 104 selectively provides operating power to the transmit circuit 110 during these transmit time intervals. This is accomplished by selective application of the transmitter power control signal from the controller 112. Similarly, the receive circuit 108 receives during receive time intervals. To reduce power consumption in the radiotelephone handset 104, the controller 112 selectively provides operating power to the receive circuit 108 during these receive time intervals.

30 To further reduce power consumption, a communication device according to the present invention removes operating power from a portion of the communication device during the transmit time intervals to reduce the peak current. The controller 112 removes operating power from the portion of the communication device to limit the output current from the voltage converter 126 to less than a maximum output current, such as 600 mA. By reducing the peak current, the voltage converter 126 remains in its operating region of maximum efficiency. By reducing the peak current, the voltage converter 126 does not draw excessive current from the battery 124, thereby extending the operating life of the battery.

5        The portion of the communication device from which operating power is removed may be any unnecessary circuit element or circuit component. Preferably, the removal of operating power is not apparent to the user of the communication device. Further, the controller also removes operating power from the portion of the communication device 10 during receive time intervals as well as transmit time intervals.

In accordance with the present invention, operating power is removed from the display 120 during the transmit time intervals. The controller 112 provides the control signal to the switch 123 and the switch 123 interrupts current flow in the plurality 136 of light emitting diodes. 15 Operating power is removed from the display 120 during a time interval imperceptible to the user of the radiotelephone handset 104.

20        The transmit time intervals preferably correspond to TDMA transmit time slots and the receive time intervals preferably correspond to TDMA receive time slots. Referring now to FIG. 2, it shows a timing diagram illustrating operation of the communication device of FIG. 1 in accordance with the present invention. FIG. 2 shows a first wave form 202 corresponding to the transmitter power control signal provided to the switch 111 by the controller 112, a second wave form 204 corresponding to the receiver power control signal provided to the switch 109 by the controller 112, and a third wave form 206 corresponding to the display control signal provided to the switch 123.

30        The transmit circuit 110 transmits to the remote transceiver 102 during transmit time slots defined by the time division multiple access communication protocol and the receive circuit 108 receives from the remote transceiver 102 during receive time slots defined by the time division multiple access communication protocol. The controller 112 removes operating power from the portion of the operating circuitry during at least one of the transmit time slots and the receive time slots to reduce peak current from the power source 122. The transmit time 35 intervals and the receive time intervals for removing power from the portion of the communication device may be longer or shorter in duration than the time slots.

40        In FIG. 2, the wave form 202 indicates that switch 111 is actuated to provide power to the transmit circuit 110 only during transmit time slots 208, 210 during which the radiotelephone handset 104 is transmitting. The switch 111 removes power from the transmit circuit 110 at times other

5 than the transmit time slots 208, 210. In the same manner, the wave form 204 indicates that switch 109 is actuated to provide power to the receive circuit 108 only during receive time slots 212, 214. The switch 109 removes power from the receive circuit 108 at times other than the receive time slots 212, 214.

10 Also in FIG. 2, the wave form 206 indicates that the controller 112 provides the display control signal to the switch 123 during transmit time intervals 216, 218. Also, the controller provides the display control signal to the switch 123 during receive time intervals 220, 222. In response to the display control signal, the switch 123 removes power from the display 120, 15 to reduce peak current from the power source 122.

20 As can be seen from the foregoing, the present invention provides a method and apparatus for reducing the peak current drawn from a DC-to-DC voltage converter in a battery powered communication device such as a cordless telephone handset. The handset enters high current operating conditions during transmit time slots and receive time slots defined by a TDMA protocol. During the receive time slots and the transmit time slots, 25 operating power is removed from a portion of the communication device, such as the display, to reduce the peak current drawn from the voltage converter. Excessive current drain from the battery and rapid battery discharge are thereby eliminated.

30 While a particular embodiment of the present invention has been shown and described, modifications may be made. For example, the invention may be applied to communication devices other than a radiotelephone handset, such as a paging receiver, or any other current-sensitive battery powered devices. It is therefore intended in the appended claims to cover all such changes and modifications which fall within the true spirit and scope of the invention.

What is claimed is:

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Claims

1. A method for reducing peak current in a communication device, the method comprising the steps of:
  - providing operating power to the communication device;
  - selectively providing operating power to a transmit circuit during transmit time intervals for transmitting from the communication device; and
  - removing operating power from a portion of the communication device during the transmit time intervals to reduce the peak current.
2. A method as recited in claim 1 wherein the communication device includes a display and wherein the step of removing operating power comprises removing operating power from the display.
3. A method as recited in claim 2 wherein the step of removing operating power further comprises the step of removing operating power from the display during a time interval imperceptible to a user of the communication device.
4. A communication device, comprising:
  - a transmit circuit for transmitting during transmit time intervals;
  - a power source for providing operating power to the communication device; and
  - a controller for removing operating power from a portion of the communication device during the transmit time intervals.
5. A communication device as recited in claim 4 wherein the portion of the communication device includes a display and a switch coupled to the controller, the switch selectively decoupling the display from the power source in response to a control signal from the controller.

5        6. A communication device as recited in claim 5 wherein the display includes a plurality of light emitting diodes coupled in series with the power source and the switch, the switch interrupting current flow in the plurality of light emitting diodes in response to the control signal from the controller.

10        7. A communication device as recited in claim 6 wherein the communication device further includes a keypad and wherein the portion of the communication device includes one or more light emitting diodes for illuminating the keypad, and wherein the switch further interrupts current flow in the one or more light emitting diodes in response to the control signal.

15        8. A communication device as recited in claim 4 wherein the power source comprises a battery and a voltage converter, the voltage converter generating an output current at an operating voltage, the controller removing operating power from the portion of the communication device to limit the output current to less than a maximum output current.

20        9. A communication device as recited in claim 8 wherein the communication device further comprises a receive circuit for receiving during receive time intervals, and wherein the controller removes operating power from the portion of the communication device during the receive time intervals.

25        30        10. A communication device as recited in claim 9 wherein the communication device operates according to a time division, multiple access communications protocol defining transmit time slots and receive time slots for the communication device, and wherein the transmit time intervals correspond to the transmit time slots and the receive time intervals correspond to the receive time slots.



The  
Patent  
Office

II

Application No: GB 9707802.6  
Claims searched: All

Examiner: Gareth Griffiths  
Date of search: 22 May 1997

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4L (LECTP, LECTX)

Int Cl (Ed.6): H04M 1/72, H04Q 7/32

Other: Online Database: WPI

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage |  | Relevant to claims         |
|----------|---|--|----------------------------|
| Y        | EP0473465 A1                              | (AUDIOVOX) col.3 line 28 - col.4 line 2 & figure 5 | 2, 5-7                     |
| X, Y     | WO96/03811 A1                             | (INTERDIGITAL) p.32 line 2 - p.36 line 30          | X: 1, 4, 8-10<br>Y: 2, 5-7 |
| X, Y     | WO95/10153 A1                             | (PACIFIC) p.9 line 18 - p.10 line 15               | X: 1, 4, 8-10<br>Y: 2, 5-7 |
| X, Y     | WO94/10812 A1                             | (SIEMENS) see figure 4                             | X: 1, 4, 8-10<br>Y: 2, 5-7 |
| X        | US5428664                                 | (KOBAYASHI) col.3 lines 45-64                      | 4                          |
| X, Y     | US5150361                                 | (WIECZOREK) col.4 line 24 - col.5 line 14          | X: 1, 4, 8-10<br>Y: 2, 5-7 |

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